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ABSTRACT

This paper identifies and analyzes the relationship between experiential science instruction, language arts, and cognitive development to provide information and recommendations concerning the integration of elementary science and language instruction. Annotated citations are provided grouped under the following categories: (1) recent status of elementary school science; (2) relationship between science experiences and cognitive functioning (cognitive skill development, cerebral lateralization); (3) relationship between experimental science and language arts (reading/reading readiness, other language arts skills); and (4) process of integrating experiential science and language arts instruction. Conclusions drawn from analysis of the annotated studies/reports indicate: a decline has occurred in the status of elementary school science in terms of instructional time and money devoted to purchase of science materials; cognitive skills can be affected by experience and science experiences enhance cognitive skill development; cerebral lateralization is linked to development of logical thinking skills; a relationship exists between science/language arts instruction and Piaget's developmental model and lateralization. Basing the recommendation on studies showing the positive effects of experiential science on language arts, the author advises that science instruction be related to language arts as much as possible. (Author/JN)

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THE INTEGRATION OF EXPERIENTIAL SCIENCE WITH LANGUAGE ARTS INSTRUCTION IN THE ELEMENTARY CURRICULUM

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INTRODUCTION

Educators involved with science instruction at all levels were faced with a revolution of sorts during the "post-Sputnik" 1960's, as the United States responded to a perceived threat from the Soviet Union's display of scientific expertise (Mallinson:6). During this period, much emphasis was place upon the importance of educating children for a scientific age. Several curriculum projects funded by the National Science Foundation were developed and widely used during the 1960's and 1970's; these and similar others are still in use today (Whitmer:168, Victor:35). The projects showed a marked change from most earlier science instruction by emphasizing the processes and concepts, rather than the memorization of facts. Learning by doing, rather than by reading and discussing, became the ideal instructional method for science (Victor:26).

In more recent years, accountability for learning and "back to the basics" have become popular emphases for education. In the elementary grades, that philosophy has frequently been translated into the practice of allotting less time and money for science instruction, while increasing the resources devoted to language arts (Rowe:19, Fulton and others:699). According to Morgan and others, "Many schools have essentially eliminated most other areas of learning (particularly in the primary grades) in an effort to provide maximum time in the school day for reading, writing, and arithmetic" (135).

The "hands on" science curricula were developed in accordance with principles of children's cognitive development, of which many have been based upon the work of psychologist Jean Piaget (National Science Teachers' Association, 1978). Many of the principles are applicable as well to children's learning and skill development in speaking,

listening, reading, and writing-the components of language arts instruction. Thus, the integration of experiential science instruction with the elementary language arts curriculum has been suggested as one means of improving education in both areas (Lucas and Burlando:769, Strickland:31, Wellman:2).

THE COGNITIVE DEVELOPMENT MODEL OF JEAN PIAGET

Piaget's model of cognitive development has been widely discussed and illustrated; a brief outline here will review the stages. The sensorimotor period, usually from birth to about age two, is characterized by the child's construction of reality as only that which s/he can immediately observe. The preoperational period, approximately from two through seven years, involves the beginning of the representation of objects through words and symbols. Intuitive, egocentric behavior is reflected in the child's continuing dependence upon her/his immediate perception of reality. In the concrete operational stage, approximately seven through eleven years, logical thinking begins to develop in relation to concrete objects only; objects can be classified, for example. Around age eleven or twelve, the child moves into the period of formal operations, which continues into adulthood. This stage is marked by the gradual development of abstract thinking, which includes working mentally with hypotheses, proportions, and multiple variables in solving problems.(Padilla, 1979:11). In Piaget's model, children progress along the continuum of stages as a result of interaction between their experiences with the environment and their current cognitive structures. Through the processes of assimilation (the "taking in" of experiences and perceptions) and accomodation (the changes in thinking or "cognitive structures" that result from the intake of new information), the child constructs a view of reality and pattern of thought that is consonant

with his/her level of development and comprehended experience (Furth,1970).

STATEMENT OF THE PROBLEM

Science instruction in the elementary school is receiving less emphasis, while language arts instruction is becoming an area of increased focus. The integration of experiential science instruction with elementary language arts has been proposed by science educators as one means of enhancing both areas.

PURPOSE OF THE STUDY

The purpose of the study was to identify and analyze the relationships between experiential science instruction, language arts, and cognitive development, in order to provide educators, program developers, curriculum organizers, and others with information and recommendations concerning the integration of elementary science and language arts instruction.

ORGANIZATION OF THE STUDY

The first part of the study examined the recent and present status of elementary science instruction. Next, the relationship between science experiences and current knowledge about children's cognitive functioning was explored, including the development of cognitive skills and the role of cerebral lateralization. Third, the relationship between elementary science experiences and language arts instruction was examined. Finally, the study considered the actual process of integrating experiential science and language arts instruction in the elementary classroom.

Within each topic or sub-topic, citations are listed chronologically, since more recent research and synthesis is built upon earlier

work.

LIMITATIONS OF THE STUDY

Several models of how learning occurs in children have been proposed by different researchers. The one most commonly used in elementary science curricula is Piaget's model of sequential cognitive development. Recent research has also begun to include cerebral lateralization as a significant factor in children's cognitive development, and to relate lateralization to Piaget's model. Since the study was intended to examine the relationships between elementary school science and language arts, citations were selected for their application to the Piagetian model of cognitive development and/or cerebral lateralization, and to the functions of those intellectual processes involved in science and language arts. As Travers noted, relatively little research on the value of elementary school science was reported prior to 1970 (1127). Many of the citations date from 1970 to 1982.

DEFINITION OF TERMS

cerebral lateralization - the specialization of each cerebral hemisphere of the brain for the processing of different types of information. The left hemisphere, in most Americans, perceives and processes information of an abstract, verbal, logical nature. The right hemisphere generally functions intuitively and creatively, working with concrete, sensory information in a holistic rather than analytic style, (Johnson, V.:43).

Elementary Science Study (ESS) - a curriculum based upon inquiry and discovery learning. Emphasis is placed on the child's directing of the learning process, (Whitmer:169).

experiential science - science instruction which "places primary emphasis on the student and his (her) direct participation" (Whitmer:168). This approach frequently, but not exclusively, uses the processes of inquiry, discovery, and investigation (Victor:25).

Science-A Process Approach (SAPA) - a curriculum which emphasizes the processes of science. Its approach is highly structured and sequential (Whitmer:169).

Science Curriculum Improvement Study (SCIS) - a curriculum which combines process and content in its emphasis (Whitmer:170).

ANNOTATIONS

THE RECENT STATUS OF ELEMENTARY SCHOOL SCIENCE

National Science Teachers' Association, "Science Education: Accomplishments and Needs," ERIC ED 171 571, ERIC Reproduction Service, 1978, 68 pp.

This report traced the development of American science education from the 1930's emphasis upon science content, through the 1960's emphasis upon science process, to the present need for basic scientific literacy for all citizens. The report described the increased use of "process" curricula during the past 20 years, and pointed out that at least 20 of 54 elementary science programs currently in use had been developed from the standpoint of learning theory. The report concluded that there is not a current need for additional new curricula, but that greater integration of science with other subject areas is needed to facilitate the use of the available curricula.

Fitch, Thomas, and Fisher, Robert, "Survey of Education in a Sample of Illinois Schools: Grades K-6 (1975-1976)," Science Education 63: 407-416, March, 1979.

The authors conducted a survey of elementary teachers, principals, science consultants, university professors, and members of the Illinois Office of Education. The 25 percent response rate came from 87 percent of Illinois school districts, excluding Cook County, to which the original survey was mailed. Major results included instructional time for science: 58 minutes per week in kindergarten, with an average increase each year of 20 minutes per week up to 205 minutes per week in grade six. Most schools used a "textbook" approach to science instruction (72 percent), rather than an activity approach (28 percent). Areas needing improvement, according to the respondents, included teacher background in science, facilities for carrying on science activities, and amounts or availability of equipment and materials. 25 percent of respondents reported the expenditure of less than 70 cents per pupil per year for science materials. The authors stressed several implications of the results, particularly the need for more use of manipulative materials.

National Science Foundation and the Department of Education, Science and Engineering Education for the 1980's and Beyond, U.S. Government Printing Office, Washington, D.C., 1980, 82 pp.

This report pointed out several characteristics of the status of American science education. Although the involvement of science and technology in Western society is increasing, the educational system, according to the authors, does not provide a thorough, practical background in science for students who do not pursue scientific careers. Students in secondary schools are taking fewer science classes than previously. Japan, Germany, and the Soviet Union provide more comprehensive science instruction for all students than does the United States. The report cited a need for basic literacy in science, to ensure the best-informed decisions possible regarding public policy related to science. (The report dealt with secondary school education and beyond; it did not consider the impact that elementary school science practices may have upon the current status of the higher levels of science education.)

Rowe, Mary Budd, "Elementary Science: A Vanishing Species," Science and Children 18:19-21, September, 1980.

Rowe examined the reports of the National Assessment of Educational Progress for the science achievement of nine and thirteen year olds for 1969 through 1977. The reports showed that achievement in physical science declined for both age groups during the period studied. Achievement in biological science showed a similar decline from 1969 to 1973, and then improved from 1974 to 1977. Rowe proposed several causes of the overall decline, including a decrease in the amount of time spent upon science instruction in the elementary school, low priority given to science instruction by elementary teachers, and little money spent upon science materials.

Fulton, Harry F. and others, "An Analysis of the Teaching of Science in the Elementary School at This Point in Time: 1978-1979," School Science and Mathematics, 80:691-701, December, 1980.

The authors surveyed 184 elementary education majors at the conclusion of their student teaching. 80 percent reported teaching science during their student teaching experience. 82 percent taught science less than 150 minutes per week; 27 percent taught it less than 30 minutes per week. (Both figures included the 20 percent who did not teach science at all.) An inquiry/discussion strategy was the most frequently used approach, by 40 percent of the respondents. In the classrooms before the arrival of the student teachers, 70 percent of the supervising teachers taught science; of those, 49 percent used an activity-based curriculum and 38 percent a textbook approach. The authors noted the similarity of the results to a survey conducted in 1972. Significant changes were found in less inquiry teaching, less time devoted to science instruction, more classrooms in which no science at all was taught, and increased reports of inadequate time to teach science. The authors suggested that if science is to be included in the elementary curriculum more regularly, it may need to be integrated with other, more "basic" areas.

Horn, Jerry G., and James, Robert K., "Where Are We in Elementary Science Education?" School Science and Mathematics 81:205-214, March, 1981.

The authors surveyed a representative sample of elementary teachers in Kansas, noting the similarity between their results and those of three National Science Foundation surveys. They reported science instruction "a poor fourth" (210) in terms of the time allocation: science averaged 88 minutes per week, in contrast to reading at 342 minutes, mathematics at 212 minutes, and social studies at 135 minutes per week. 42 percent of the respondents reported the use of hands-on science equipment at least once a week. Major problems reported by teachers included lack of planning time for science, lack of instructional time coupled with a perception of science as unimportant, and lack of assistance in obtaining information about new curricular methods and materials.

Gallagher, James Joseph, and Yager, Robert E., "Science Educators' Perceptions of Problems Facing Science Education: A Report of Five Surveys," Journal of Research in Science Teaching 18:505-514, September, 1981.

These surveys included five groups of educators seen by the authors as "leaders" in science education. In the 100 percent response, several broad categories of concerns emerged which a majority of participants had addressed. These included conceptual organization (lack of a clear theoretical base for science education), lack of leadership, poor organization, and lack of contact between university faculty and teachers in schools. The authors included recommendations for elementary schools: specifying a theoretical base upon which to organize science education, and providing better communication between researchers and teachers so that research findings can provide clearer direction to the teaching of science.

THE RELATIONSHIP BETWEEN SCIENCE EXPERIENCES AND COGNITIVE FUNCTIONING

The Development of Cognitive Skills

Almy, Millie, and others, Young Children's Thinking, Teachers' College Press, Columbia University, New York, 1966, 153 pp.

This book, frequently cited as a resource by science education researchers, contained the results and educational implications of several studies by the authors of Piaget's ideas. In general, the results supported Piaget's model. The most specific finding was that skill in conservation was correlated with reading readiness. The authors stressed that merely attempting to teach children specific cognitive skills would not, in itself, speed up development. Their major implications for education included providing a broad range of activities, since research had not shown whether variety or sequence was more important, as well as combining activities and verbalization to promote learning most effectively.

Johnson, Janice K., "Effects of the Process Approach Upon IQ Measures of Disadvantaged Children," Science Education 54:45-47, January-March, 1970.

Using the California Test of Mental Maturity as a measure of the ability to "think rationally," Johnson tested the effects of 15 lessons from SAPA and ESS upon rational thinking. All 15 experimental and 15 control grade three subjects were from disadvantaged backgrounds and attended a Title I school. Both groups significantly improved their California Test score from pretest to posttest; the experimental group also improved significantly more than the control. (The scores used were averages of verbal and nonverbal measures.)

Linn, Marcia C., and Peterson, Rita W., "The Effect of Direct Experience with Objects on Middle Class, Culturally Diverse, and Visually Impaired Young Children," Journal of Research in Science Teaching 10:83-90, no. 2, 1973.

Linn and Peterson performed two experiments testing the effects of a unit from SCIS upon first graders' classification skills. In the first, culturally diverse and visually impaired children who had participated in science activities scored significantly higher than their controls. For middle class subjects, treatment was unrelated to performance. Also, even with the advantage of science experiences, the culturally diverse and visually impaired subjects scored significantly lower than middle class children. In the second experiment, similar results were noted. The authors concluded that, in accordance with Piagetian theory, manipulative experience is one prerequisite to logical thinking.

Allen, Leslie R., "An Examination of the Ability of Third Grade Children from the Science Curriculum Improvement Study to Identify Experimental Variables and to Recognize Change," Science Education 57: 135-151, April-June, 1973.

Allen tested the effects of an SCIS unit upon the logical thinking tasks identifying variables and recognizing change, in third grade children. Allen controlled groups for socioeconomic level, having 176 total subjects. Results showed that the experimental subjects, who had received instruction with the experiential unit, performed significantly better than the controls at all three socioeconomic levels, on both types of tasks.

Breddeman, Ted, "Elementary School Science Experience and the Ability to Combine and Control Variables," Science Education 58:457-469, October-December, 1974.

Breddeman tested 240 upper middle class subjects from grades four, six, eight, and ten on their ability to use variables in the manipulation of objects. Each grade level was divided according to the type of previous instruction in science that subjects had previously received: SAPA, laboratory orientation with a science specialist, or no formal program of science instruction. Breddeman found no significant differences between groups due to previous science education. (He did find that older students consistently performed better than younger ones.)

Linn, Marcia C., and Thier, Herbert D., "The Effect of Experiential Science on Development of Logical Thinking in Children," Journal of Research in Science Teaching 12:49-62, January, 1975.

Logical thinking skills as dealt with in SCIS were tested with fifth grade students by the authors. The 2290 subjects from seven states were divided into experimental and control fifth grade, and one eighth grade group, and tested on tasks involving combinations of variables. For rural, suburban, and urban fifth graders, groups who had participated in SCIS activities performed significantly better on the logical thinking tasks than did the controls. In addition, the experimental fifth graders scored closer to the eighth graders (none of whom had used the SCIS activities involved), than to the control fifth graders. The authors noted that learning to specify variables and manipulating materials to perform experiments may have been the particular experiences which enhanced the growth of the experimental subjects' logical thinking.

Espejo, Mila, and others, "Evaluation of a Child-Structured Science Curriculum Using the Intellectual Models of Piaget and Guilford," Journal of Research in Science Teaching 12:147-155, no.2, 1975.

The authors applied Piaget's model of cognitive development to specific skills from Guilford's Structure of Intellect model. They devised eight groups of tasks which corresponded generally with Piagetian stages and specifically with components of the Structure of Intellect model. The 23 experimental first grade subjects had worked with the Child-Structured Learning in Science program; the 50 control students had not. The groups were matched for socioeconomic level. The authors found significant differences on the tasks relating to classification and spatial skills. They concluded that some science activities, when matched to the cognitive levels of the children involved and designed to develop specific skills, could enhance intellectual development.

Thiel, Robert P., and George, Kenneth D., "Some Factors Affecting the Use of the Science Process Skill of Prediction by Elementary School Children," Journal of Research in Science Teaching 13:155-166, March, 1976.

Thiel and George tested the effects of four factors upon the use of prediction: experience, inference and applying rules, type of rules used, and complexity of the task. 30 students from each of grades three, four, and five whom the authors evaluated as concrete operational were tested on tasks involving prediction. Half of the children at each grade level were given a verbal description of the "rule" governing each task; the remainder were given the task without a description of the rule. The authors found no significant differences between groups for any factor at any grade level; there were also no significant differences between grade levels. Relating their findings to the four factors tested, the authors concluded that experience with science activities may enhance prediction skills which a child has already developed. Also, they noted that skill in prediction appears to develop regardless of exposure to science activities, as the subjects had not been involved in a process oriented science curriculum. The authors' major implication for education was that merely verbalizing a "rule" does not imply comprehension or the ability to apply it.

Breddeman, Ted, "Elementary School Process Curricula-A Meta-Analysis," ERIC ED 170 333, ERIC Reproduction Service, 1978, 12 pp.

Breddeman described the main emphases of the three main process curricula, which an estimated 33 percent of American elementary students were using during the early 1970's. Breddeman selected 60 studies which tested the effectiveness of the three curricula upon numerous factors. Criteria for selection included the use of control groups, repeated means, and standard deviations. He found that highly structured, direct teaching provided the best results upon measures of convergent thinking. Also, open-ended approaches affected creativity the most positively. According to Breddeman's analysis, SAPA made no significant difference overall in either science content or language arts achievement. He concluded that if one aspect of instruction received particular emphasis in a science curriculum, other areas were subsequently under-emphasized. (Breddeman stated that a computer analysis of the effects and interactions of 34 variables common to many of the studies was incomplete at the time of this publication. That analysis would certainly have made his conclusions more tenable.)

Epstein, Herman T., "Growth Spurts During Brain Development: Implications for Educational Policy and Practice," Education and the Brain, Jeanne S. Chall and Allan F. Mirsky, eds., University of Chicago Press, Chicago, 1978, pp. 343-370.

Epstein related several findings of brain research to Piagetian stages of cognitive development, pointing out that while Piaget's ideas explain observed behavior, they fail to provide any physical evidence for actual changes through the stages. He defined phrenoblysis as "correlated brain and mind growth spurts" (348), to be distinguished from separate growth of brain tissue or mental processes. Epstein pointed out several implications for education of this synthesis of the growth of brain and mind. First, providing the most stimulation and challenges during growth spurts would take advantage of the most opportune time for learning. Second, lower level skills, such as drill and memorization, may be most appropriate for "plateau" periods. Third, the general goal of schooling should be to provide children with the mental and physical preparation needed to proceed effectively with the developmental stages.

Chall, Jeanne S., and Mirsky, Allan F., "The Implications for Education," Education and the Brain, University of Chicago Press, Chicago, 1978, pp. 61-102.

Chall and Mirsky stated several educational implications of the research reported by contributors to the book. They pointed out the evidence that education and environmental stimulation contribute to actual brain development, and that proper development depends upon appropriate timing of experiences. In regard to cerebral lateralization, they noted that engaging the already-functioning right hemisphere would take advantage of children's natural means of processing information. They also pointed out the relative tentativeness of current theories about brain function in children, and stressed the need for educators to be flexible in their approaches.

Kishta, Mohammed A., "Cognitive Levels and the Linguistic Abilities of Elementary School Children," Journal of Research in Science Teaching 16:67-71, January, 1979.

Kishta hypothesized that if language and logical thought are dependent upon the development of cognitive structures, the relationship between language and thought has important implications for the teaching of elementary school science. He compared 85 fourth, fifth, and sixth grade students on four Piagetian tasks and upon language development as measured on the Iowa Tests of Basic Skills (ITBS). He found that for three of the four tasks, students who performed the Piagetian tasks successfully also scored significantly higher on the Language portion of the ITBS. He concluded that his findings supported the Piagetian model of cognitive structures as prerequisites to language-oriented learning. He recommended that teachers adjust their instruction to the cognitive levels of students, and provide many hands-on experiences to enhance the cognitive development from which language could originate.

Padilla, Michael J., and Smith, Edward L., "Experimental Results of Teaching First Grade Children Strategies for Nonvisual Seriation," Journal of Research in Science Teaching 16:339-345, July, 1979.

Padilla and Smith attempted to determine the effects of teaching two different types of ordering upon the transfer of ordering skills. They found that the only significant effect was upon the short-term transfer of the seriation strategy of ordering objects according to the greatest value of a characteristic. The authors also pointed out that one third of the children who started at the lowest level of seriation skill had advanced into the next two levels after three weeks' exposure to the training materials. They concluded that their results showed to a marginal extent that children's seriation ability could be improved through concrete experience.

Wollman, Warren, and others, "An Analysis of Premature Closure in Science and Developmental Stages," Journal of Research in Science Teaching 17:105-114, March, 1980.

The authors defined the avoidance of premature closure as the ability to avoid making "final" inferences about the variables involved in a task or observation until complete information was available. They tested 141 pupils in grades one through six for the effects of training to avoid premature closure, and its transference to new tasks. They found that training made no significant difference for any age group in inferential ability. They suggested that this aspect of making correct inferences may be a gradually developed one which is at least partially dependent upon the child's experiences in interacting verbally with logically-thinking adults.

Cohen, Herbert G., "Effects of Science Instructional Method upon Cognitive Development," ERIC ED 183 377, ERIC Reproduction Service, 1980, 11 pp.

Cohen discussed the four factors that, according to the Piagetian model, facilitate cognitive development: experience, maturation, social transmission, and equilibration. Of these, he noted that experience is the one that is most measurable. He studied the correlation between exposure to one half year of SCIS instruction and performance on six Piagetian tasks chosen to give a complete picture of the subjects' cognitive development. There were 18 subjects in each of a control and experimental group from grades one, three, and five. Gohen found no significant difference between groups at any grade level. He suggested that, if SCIS were to have any effect, a longer period of exposure to it would be necessary.
(Cohen's criterion for success on the Piagetian tasks was that all answers had to be correct. This was more stringent than for some other studies of this type, which may have influenced his results.)

Cerebral Lateralization

Hunter, Madeline, "Right-Brained Kids in Left-Brained Schools," Today's Education 65:45-48, November/December, 1976.

Hunter described results of recent research on lateralization and the implications for education. She identified "Integrated brain thinking" as the outcome of one's use of both hemispheres to process information. She pointed out the disadvantages to students of using only the traditional verbal, "left hemisphere" approach to learning: pupils with a greater tendency for left hemisphere use receive little opportunity to develop their right hemisphere potential, while those whose strength may lie in right hemisphere functioning are denied much of a chance to use their relative area of strength to learn. Hunter expounded upon the implications of lateralization for teachers, including the idea that knowing what research shows, educators have a responsibility to present information so students have a chance to use both hemispheres to learn. In addition, teachers can supplement their instruction for students having difficulty, by presenting information in a form compatible with the functions of the "other" hemisphere. Finally, teachers can improve the effectiveness of instruction by teaching to each hemisphere singly and/or to both simultaneously.

Kraft, Rosemarie Harter, "An EEG Study: Hemispheric Brain Functioning of Six to Eight Year Old Children During Piagetian and Curriculum Tasks with Variation in Presentation Mode," Ph.D. dissertation, The Ohio State University Press, Columbus, OH, 1976, 314 pp.

Kraft tested 18 right-handed children for EEG evidence of hemispheric functioning during tasks involving Piagetian skills and the curricular skills of reading, logic, and mental arithmetic. She found several significant response differences related to hemispheric functioning and facet of the response (whether initial, when the child was first confronted with the tasks, or subsequent, when s/he was providing the answer). On two of the conservation tasks, there was significantly more right hemisphere activity during the initial response phase, and more left hemisphere activity during the subsequent phase. During silent reading, there was more right hemisphere activity than when the children were answering oral comprehension questions. There were significantly positive correlations between the hemispheres used for: the initial response of Piagetian tasks and silent reading, the subsequent response on Piagetian tasks and oral reading, and the verbal, logic, mathematics, and block design compared with similar types of tasks in reading, mathematics, and spatial tasks. Kraft also noted that higher achievers on the tasks tended to show higher levels of activity in both hemispheres, suggesting that they were facilitating their left hemisphere responses with information from the right hemisphere.

Bratt, H. Marvin, "Hemisphere Asymmetry in School Age Children," School Science and Mathematics 79:158-169, February, 1979.

Bratt tested third and sixth grade children for evidence of asymmetric brain function, using a modified Kohs Block Design for evidence of right and the Cloze Procedure in reading for evidence of left hemisphere functioning. He found that both third and sixth grade children performed significantly better on the right henisphere Block Design tasks than on the left hemisphere Cloze Procedure. Bratt concluded that if the elementary child does indeed use the right hemisphere more effectively than the left (as several of his sources suggested), instructional activities engaging the right hemisphere in learning would be more effective than many current approaches. Particularly pertinent to the classroom setting, Bratt suggested that a child can perhaps only truly comprehend a concept verbalized via the left hemisphere when the right hemisphere has also been actively involved in learning.

Billings, Gilbert, "Do Verbal Labels Help Children Acquire Science Concepts?" School Science and Mathematics 79:287-293, April, 1979.

Billings tested second grade pupils for the effects of verbal plus concrete, concrete only, and no formal presentation, for their attainment of the concepts of interaction and evidence of interaction from SCIS. He designed a Concept Acquisition Test using manipulative objects, which was used as a pre- and posttest. Having determined no significant differences in knowledge of the concepts before training, Billings did find a significant difference between the control group and the experimental group receiving only concrete instruction. No such difference was found between the control and the group receiving concrete instruction with verbal labels. Billings concluded early elementary children may learn science concepts most readily when presented in a nonverbal (right hemisphere) approach.

Cole, Henry P., "Piaget's Theory of Cognitive Representation and Brain Hemisphere Functioning," Educational Technology 20:38-40, December, 1980.

Cole synthesized several stages in the Piagetian model of cognitive development with recent findings in lateralization research. He presented evidence that, rather than involving exclusively left hemisphere function, Piaget's theory encompasses right hemisphere activities as well. Cole pointed out that during the sensorimotor, preoperational, and into the concrete operational stages, children function as if the right hemisphere were dominant: their thinking is largely intuitive rather than logical or analytic. In addition, the process of assimilation may be considered a logical, left hemisphere function, while accomodation is a type of holistic, right hemisphere process. Cole summarized his synthesis by pointing out that the integration of the complementary functions of the two hemispheres leads to further cognitive growth.

Epstein, Herman T., "Some Biological Bases of Cognitive Development," Bulletin of the Orton Society 30:46-61, 1980.

Epstein related spurts in brain growth to Piagetian stages in cognitive development. He noted that during periods of brain growth, connections between neural cells restructure, forming more complex connections which make more complex reasoning possible. As evidence of this restructuring, he cited studies showing changes in EEG patterns, which coincide with the latter ages associated with Piagetian stages. He asserted that experience and teaching "sharpen" the "neural networks" (56) that make sensory integration, concept formation, and logical thinking possible. He summarized by pointing out that "Brain, language, logic, and reading-all develop together." (61)

Johnson, Virginia R., "Myelin and Maturation: A Fresh Look at Piaget," The Science Teacher 49:41-44,49, March, 1982.

In reviewing recent publications relating the findings of brain research to educational procedures, Johnson described three areas in which more appropriate instruction could enhance learning: periods of physical development of the brain, attention mechanisms, and cerebral lateralization. She suggested providing more concrete, sensory experiences in science to promote physical/cognitive development of the brain, the use of unusual, attention-focusing events to use optimal attention levels in illustrating concepts, and the use of sensory information to stimulate the right hemisphere while using already common verbal activities to engage the left.

THE RELATIONSHIP BETWEEN EXPERIENTIAL SCIENCE AND LANGUAGE ARTS

Reading and Reading Readiness

Lepper, Robert E., "Cross-Cultural Investigation of the Development of Selected Piagetian Science Concepts, Social Status, and Reading Readiness," Journal of Research in Science Teaching 5:324-337, no. 4, 1957-1968.

Lepper examined the relationship between the performance of Piagetian tasks involving conservation, and scores on the Metropolitan Reading Readiness Test, for Caucasian and Negro first graders. He found that Caucasian children scored significantly higher on conservation of number, length, and area, but not on conservation of substance. In addition, he found that conservation performance correlated significantly with reading readiness. Lepper concluded that much of the observed difference was due to variations in experience. He suggested that students should not be grouped together for science instruction on the basis of reading readiness, pointing out that the correlation between the two was only marginally significant.

Ayers, Jerry B., and Mason, George E., "Differential Effects of Science-A Process Approach upon Changes in Metropolitan Readiness Test Scores among Kindergarten Children," The Reading Teacher 22:435-439, February, 1969.

In addition to a regular kindergarten program which stressed readiness skills, the experimental group in Ayers and Mason's study also received 22 lessons from Part A of SAPA. The control and experimental groups were pre-and posttested on the Metropolitan Readiness Test, and showed no significant IQ differences as measured on the Stanford-Binet Intelligence Scale. The experimental group gained significantly more than the control on listening, numbers, and copying. The control group gained significantly more in word meaning. Both groups, when compared with their own pretest, gained significantly in total test score. The authors concluded that traditional kindergarten led to increased readiness, and that parts of SAPA could further inhance readiness, particularly in skills related to discrimination, categorization, and labeling.

Neuman, Donald B., "Effect of Kindergarten Science Experiences on Reading Readiness-Final Report," ERIC ED 044 264, ERIC Reproduction Service, 1970.

Neuman devised several science tasks to promote visual and tactile discrimination skills. His experimental group of 24 kindergarten students received a school year's instruction with the materials in addition to usual kindergarten experiences. The control group, chosen to match the socioeconomic and intellectual characteristics of the experimental subjects, received regular kindergarten instruction without science materials. On both the Metropolitan Reading Readiness Test and subsequent tests of first grade reading achievement, the experimental group scored significantly higher than the control.

Ayers, Jerry B., and Ayers, Mary N., "Influence of SAPA on Kindergarten Children's Use of Logic in Problem Solving," School Science and Mathematics 73:768-771, December, 1973.

The authors approached six Piagetian conservation tasks from the perspective that ability to conserve had been correlated with reading readiness. They tested two groups of 20 kindergarten children each; the variable tested was the exposure of the experimental group to SAPA. The experimental group was found to achieve significantly higher on all tasks except the conservation of numbers, and copying, from the Metropolitan Readiness Test. Since there had been no significant difference in intelligence, the authors concluded that SAPA could be useful in the development of reading readiness.

Lucas, Stephen B., and Burlando, Andrew A.,"The 'New Science Methods' and Reading," Language Arts 52:769-770, September-December, 1975.

The authors pointed out the difficulty faced by many elementary teachers in attempting to cover all subject areas on a regular basis. They proposed dealing with this difficulty by integrating science and reading instruction whenever possible. They pointed out several skills which could improve both science and reading skills: adjusting reading rate to the type of reading at hand, using reference and study skills, using science vocabulary, reading graphs and tables, analyzing paragraphs for meaning and details, reading and understanding directions, interpreting results and reading material, and applying reading material to concrete situations.

Barufaldi, James P., and Swift, Jennifer Wallenfels, "Children Learning to Read Should Experience Science," The Reading Teacher 30:388-393, January, 1977.

Barufaldi and Swift identified several skills common to the reading process and to science experiences as found in four of the major science curricula. The skills included observing, classifying, communicating, comparing, inferring, and predicting.

Morgan, Ashley, and others, "Sciencing Activities as Contributors to the Development of Reading Skills in First Grade Students," Science Education 61:135-144, April-June, 1977.

The authors tested the effect of an inquiry-based science curriculum, SCIS, upon the reading achievement of first grade students. As measured on the Houghton Mifflin SBA reading skills test, the experimental group performed significantly better than the controls. They suggested that science activities could have a positive effect on motivation for school achievement, and on oral communication skills.
(A major discrepancy in this study was the use of one test as the pretest-a local district-developed test-and the use of the SBA as the posttest. As the authors pointed out, the two tests were not analyzed statistically to ensure reliability.)

Carter, Glenda S., and Simpson, Ronald D., "Science and Reading: A Basic Duo," The Science Teacher 45:19-21, March, 1978.

From a review of the literature on the teaching of reading, the authors gleaned several skills which are involved in both science and reading processes. They focused on logical thinking as the basis for many processes in both areas. Logical thinking skills which are most applicable to elementary reading include observing, identifying, describing, classifying, interpreting, and forming conclusions.

Hopper, Jack M., "The Impact of Accountability on Science Education in Florida," Science and Children 16:16-18, October, 1978.

Hopper discussed the "pioneering efforts of Florida" (16) in the testing of basic skills. He pointed out the low priority given to science instruction and testing, in spite of the finding that the lowest correlation between a school district's primary reading and science performance on recent statewide competency tests was .57. In addition, he pointed out that Florida counties with the top ten average test scores had typically not reduced their programs, and in some cases had added teachers of science at the elementary level.

Quorn, Kerry Charles, and Yore, Larry Dean, "Comparison Studies of Reading Readiness Skills Acquisition by Different Methods: Formal Reading Readiness Program, Informal Reading Readiness Program, and a Kindergarten Science Program," Science Education 62:459-465, October-December, 1978.

The authors conducted two studies to test the effects of several supplementary approaches to reading readiness instruction on groups of 12 kindergarten students. In the first study, SAPA and a program of picture cards, worksheets, and tape recordings were found to have no significant effect upon the attainment of reading readiness skills. The second study tested the effects of SAPA, the program described previously, and an informal discussion approach to enhance oral expression. This study, too, found no significant differences.

Merricks, Anne R., and Crocker, Robert K., "The Influence of Science Process Activities and Selected Science Reading Materials on Reading Achievement of First and Third Grade Pupils," School Science and Mathematics 78:684-690, December, 1978.

Merricks and Crocker reviewed the role that perceptual skills and logical thinking play as prerequisites to reading. In addition, they asserted that motivation through concrete experiences could help children to "expend more effort in reading." In testing first and third grade students, they used science activities plus science reading materials, science activities alone, science reading materials alone, and no science approach with the controls. They found that for both age groups, the experimental groups scored significantly higher on the Gates-McGintie reading test than did the controls on comprehension, but not for vocabulary. Also, for first grade students there was a significant difference in comprehension between experimental groups: the process curriculum with supplementary reading materials was more effective.

Wellman, Ruth T., "Science: A Basic for Language and Reading Development," What Research Says to the Science Teacher, Mary Budd Rowe, ed., National Science Teachers' Association, Washington, D.C., 1978, pp. 1-12.

Wellman reviewed several studies of the relationship between experiential science and language development. She presented evidence in support of several conclusions. First, science activities appear to promote the development of language and logical thinking. Second, science activities are particularly helpful in the development of children from impoverished environments. Third, some science activities can promote reading readiness. Finally, science activities can serve as the stimulus for and the content of language arts instruction.

Fuller, Ellen W., and others, "The Science Achievement of Third Graders Using Visual, Symbolic, and Manipulative Instructional Treatments," Journal of Research in Science Teaching 16:129-136, March, 1979.

The authors tested the idea that science concept achievement would be influenced by reading level and/or the method of instruction involving science concepts. They found, for the 133 third grade students tested, no significant differences related to instructional method. (The three methods in question were overhead projector transparencies with discussion, written booklets with discussion, and jigsaw puzzles with flashcards.) Reading achievement was found to significantly correlate with science concept attainment in students with highest and lowest reading performance, even on the tasks using nonverbal material.

Other Language Arts Skills

Huff, Phyllis, and Lenguis, Marlin, "The Effects of the Use of Activities of SAPA on the Oral Communications Skills of Disadvantaged Kindergarten Children," Journal of Research in Science Teaching 10:165-173, no. 2, 1973.

A pretest of the experimental and control groups in this study showed no significant difference in oral communications skills. Following instruction with either SAPA or the more "conventional" teacher demonstration-class discussion approach, the posttest results showed a significant advantage for the SAPA group in language output, vocabulary, general meaning, sentence structure, defining words, and listening behavior. No significant differences were found for average sentence length or listening comprehension. The authors concluded that some components of speaking skills in disadvantaged children could be improved through science experiences.

Barufaldi, James P., and Swift, Jennifer W., "The Influence of the BSCS Elementary School Science Program Instruction on First Grade Students' Listening Skills," Journal of Research in Science Teaching 17:485-490, September, 1980.

The authors pointed out several skills common to science activities, reading, and listening: observation, identification, naming, classification, prediction, inference, and communication. To test the effect of science experiences relating to sound and listening, they tested first grade students using the Cooperative Primary Series Listening Test as a pre-and posttest. The test measured total performance as well as the specific skills of identification, recall/remember, and interpretation/inference. The results showed significant improvement in total listening scores for students whose pretest scores were above the mean. For the three specific items examined, no sigvificant differences were found. In addition, socioeconomic was found to be related significantly to total listening score within the experimental group. The authors concluded that students "with the requisite ability" could benefit from science activities related to listening skills.

THE PROCESS OF INTEGRATING EXPERIENTIAL SCIENCE AND LANGUAGE ARTS INSTRUCTION

Donlan, Dan, "Science Writing: A Call for Continuing Education," The Science Teacher 42:19-20, December, 1975.

Donlan described a survey he conducted in 1974 of 123 elementary and secondary teachers. He found that teachers in all content areas made writing assignments. Donlan suggested that at all levels, teachers teach writing skills through the recording and elaborating upon science observations. He proposed helping students, when appropriate, to observe and use several styles of writing commonly used with science: relating history, analyzing, and describing processes.

Esler, William K., and Merritt, King, Jr., "Teaching Reading Through Science Experience Stories," School Science and Mathematics 76: 203-206, February, 1976.

The authors proposed using science experiences and observations for the basis of experience stories in primary language arts and reading instruction. The authors pointed out several benefits of this approach to science/language instruction. First, since the pupil is directly involved in visualizing and handling the subject of communication, the verbal aspects acquire a deeper meaning than from a purely verbal/pictorial approach. Second, experience stories tie together the processes of listening, speaking, reading, and writing. Third, said the authors, integrating science and language arts could eliminate some teacher preparation time by combining several subjects into one "preparation."

Carter, Martha A., "A View from the Top: Elementary Science and the Three R's," The American Biology Teacher 40:146-147,163, March, 1978.

Carter used the Educational Policies Commission's basic purpose for education as "'the development of the ability to think'" (163) as the basis for this report of her experience as a classroom teacher in integrating science, reading, and writing through skills such as observation, prediction, classification, and discussion. She emphasized the importance of the individual teacher's role in seeking to integrate science experiences with language arts.

Bishop, Jeanne E., "Astronomy and Space Science in the Elementary Curriculum? Yes!" School Science and Mathematics 79:183-190, March, 1979.

Bishop related research in lateralization to the use of astronomy as a vehicle for relating science to right hemisphere processes, and to other areas of the elementary curriculum. She suggested that time and space concepts, aesthetic awareness, creativity, and learning by analogy are areas in which astronomy can contribute to integrating science with other subjects. She also pointed out the need for more resources for teachers in this area.

Rice, Dale R., and Sisk, Preston F., "Teaching Elementary Science Through Creative Dramatics," School Science and Mathematics 80:61-64, January, 1980.

Based on their experience and review of recent research, the authors proposed a rationale for including creative dramatics in elementary science instruction. In particular, they focused on the imaginal role that the right hemisphere can play in complementing the left hemisphere's chiefly verbal function.

Simon, Marylu Shore, and Zimmerman, Judith Moss, "Science and Writing," Science and Children 18:7-9, November/December, 1980.

The authors suggested the use of practice with expressive writing skills, with science experiences as motivators, to enhance writing ability. They gave several specific ideas for integrating writing with science activities in the elementary classroom which had proven successful in their own work. They found that expressing ideas and observations in written form helped children to analyze and clarify concepts in order to communicate clearly. In turn, the mental processes developed through writing clearly helped students to observe more astutely and to think more logically about science phenomena.
(The suggestions discussed in this section would carry much more weight if they were tested "scientifically." However, they are intended to provide an idea of the types of activities which can promote the integration of science experiences and language arts.)

SUMMARY

Several studies on the current status of elementary school science instruction found a decline over the last decade in the priority given to science instruction. This was evident in the relatively little amount of time allotted for science in comparison with other subjects, and in the amount of money devoted to science materials at the elementary level. Other factors cited by educators as needing improvement included lack of adequate preparation time, inadequate teacher preparation in science teaching methods, and lack of an organized, consistent theoretical base for science education. The National Science Teachers' Association, while noting the use of learning theory in the development of science curricula, pointed out the need for more effective use of the curricula already available. More recent recommendations involved integrating science with other curricular areas.

The relationship between experiential science and cognitive development was seen by most authors as involving logical thinking skills. The major skills which were tested include classification, the use of variables, inference, prediction, and seriation. The majority of the studies reported that cognitive skills could be affected by experience, and/or science experiences enhanced the development of cognitive skills.

Some of the more recent studies linked cerebral lateralization to the development of logical thinking skills. As Epstein noted, "Brain, language, logic, and reading-all develop together." (61) The prevalent view from lateralization research appears to be that in children of elementary school age, initial information is more readily processed by the nonverbal right hemisphere. Meaningful, logical communication occurs through the left hemisphere if the right has been sufficiently involved in grasping meaning. Cognitive development then occurs as

children learn to integrate the functions of the two hemispheres, via a combination a nonverbal experiences and verbal interactions with others.

Science and language arts instruction relate to Piaget's model of cognitive development and to lateralization findings in several ways. First, science activities stimulate the right hemisphere, which may be the child's chief avenue for comprehension. Second, science activities serve as both an experiential base and as content out of which meaningful language can grow. Third, the capability for reading, writing, listening, and speaking emerge as the child's physical development and experiences interact.

Consistent with the relatively large proportion of time allotted for reading instruction in the elementary school, the most research dealing with the effects of science experience upon language arts involved measures of reading readiness or reading skills. Several researchers found significant positive effects of science upon reading and readiness; others found that science activities appeared to make no difference. There was quite a large variation in the specific skills tested, the materials and activities used, and the testing techniques employed. Very little research has been done to test the effects of science instruction upon writing, listening, or speaking.

The prevalent trend, based on the studies showing positive effects of experiential science upon language arts, appeared to be toward recommending that science be related to language arts as much as possible. Although several specific "integrating" activities had not been tested empirically, experienced teachers made recommendations for the practical applications of such activities.

CONCLUSIONS

Although science is receiving less time than the more "basic" subjects (reading and mathematics, in particular), the processes of science are certainly important. In an increasingly technological society, basic familiarity with and knowledge of science concepts and processes, as well as content, is important for well-informed citizens. In addition, many of the processes involved in scientific learning, especially at the elementary school level, are also involved in the learning of the "basics."

The activities involved in experiential science instruction, by virtue of sharing several processes needed for the learning of language arts components, appear to have at least some potential for enhancing cognitive development. This, in turn, can pave the way for the most meaningful language development, as expressed through reading, writing, listening, and speaking.

Research in the physical development of the brain promises to provide clearer understanding of the physiological bases of the cognitive development model of Piaget, among others. Lateralization research, in particular, seems to point to at least a partial explanation of the "why" behind Piaget's idea that children's pre-formal learning must first occur nonverbally to be meaningful.

There are a variety of suggestions in the literature of ways in which teachers can integrate elementary science and language arts instruction. Those contained in the available "process" curricula have been tested to some degree, and may be most accessible for some teachers.

RECOMMENDATIONS

It is recommended that:

1. Teachers of elementary school students orient science instruction toward active manipulation of materials by students.
2. Where possible, teachers integrate science experiences with components of the language arts program.
3. Teachers supplement their appraisals of individual children with future findings about cognitive functioning, in order to determine the most appropriate instructional strategies.
4. Researchers attempt to identify and test in a more uniform manner the processes and skills involved in cognitive functioning, in order that the most appropriate instructional strategies may be developed.

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APPENDIX

SKILLS IMPORTANT TO BOTH SCIENCE AND READING

Examples of Problem-Solving Skills in Science	Corresponding Reading Skills
Observing	Discriminating shapes Discriminating sounds Discriminating syllables and accents
Identifying	Recognizing letters Recognizing words Recognizing common prefixes Recognizing common suffixes Recognizing common base words Naming objects, events, and people
Describing	Isolating important characterisitcs Enumerating characteristics Using appropriate terminology Using synonyms
Classifying	Comparing characteristics Contrasting characteristics Ordering, sequencing Arranging ideas Considering multiple factors
Collecting data	Taking notes Surveying reference materials Using several parts of a book Recording data in an orderly fashion
Interpreting data	Recognizing cause and effect relationships Organizing facts Summarizing new information Varying rate of reading Inductive and deductive thinking
Communicating results	Using graphic aids Logically arranging information Sequencing ideas Describing with clarity
Formulating conclusions	Generalizing Analyzing critically Evaluating information Recognizing main ideas and concepts Establishing relationships Applying information to other situations

Source: Carter and Simpson:20

BACKGROUND

Name: Carla Griebel Mishler

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Rationale: The study of elementary science instruction as it relates to language arts has several implications for future work, based upon prior experience and preparation of the writer. First, science content was a significant part of her undergraduate preparation. Second, language arts instruction has been the major focus expected in grade 3, public school teaching. Integration of the two areas suggested a way to accomodate the school district's emphasis upon language arts, while providing more opportunity to use the writer's science background. This study has provided a better understanding of how elementary science instruction can most effectively enhance children's learning, based upon research in the field. The writer's previous study of "gifted education" also provided some background in cognitive development and functioning, which was further advanced through this study.